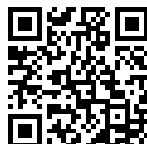

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INFLUENCE OF FLESH-EATING
ON ENDURANCE

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The Influence of Flesh-Eating on Endurance

BY IRVING FISHER, PH. D.
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THE INFLUENCE OF FLESH-EATING ON ENDURANCE

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As yet the science of physiology seems to have given very little attention to the study of endurance. The nature of endurance, its relation to strength and fatigue, and, above all, the factors on which endurance depends, denote fields almost unexplored. Even the concept of endurance seems never to have been formulated. That strength and endurance are not identical is only partially recognized. The strength of a muscle is measured by the utmost force that it can exert once; its endurance, by the number of times it can repeat a given exertion within its strength. The repetition of such exertion, if not stopped by the refusal of the will, is finally stopped by the reduction of the strength of the muscle until it is unable to perform further. Thus endurance may be expressed in terms of *loss of strength*. It is related to *fatigue*, and it is only through the studies on fatigue and fatigue poisons made by Mosso and others, that light has been thrown on the nature of endurance.

The object of the experiments described below was to determine the relations of certain dietetic factors to endurance, particularly the factors of protein and flesh foods. Several lines of study were entered upon with this object in view, one of which has been already described. This was the mastication experiment on nine healthy Yale students. It was commented upon in the last number of this *Journal*. The results of this experiment have been communicated to the Connecticut Academy of Arts and Sciences, and a full report will soon be published in its *Transactions*.

The present experiment consists of endurance tests made on forty-nine persons representing two contrasted types of dietetic habits. These fall into

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three groups: first, athletes accustomed to a high-protein and full-flesh dietary; second, athletes accustomed to a low-protein and non-flesh dietary; third, sedentary persons accustomed to a low-protein and non-flesh dietary. The subjects consisted of Yale students and instructors, a Connecticut physician, and some of the physicians, nurses, and employees of the Battle Creek Sanitarium. The personnel of the last named institution was selected as representing abstainers from flesh foods. All of the subjects except one had abstained from flesh foods for periods from four to twenty years, and five of them had never eaten such foods. The exception had abstained for two years only.

Among the other subjects, all of whom live in New Haven or vicinity, inquiry showed that, with four exceptions, they were accustomed to eat meat two or three times daily, and presumably consumed protein in ordinary amounts (excreting about 15 to 20 grams of nitrogen, or about .18 to .24 grams per kilogram of body weight). Of the remaining four, one, W. W., had abstained from flesh foods for two years; another, I. F., had for several years followed the Chittenden régime of low-protein, and used flesh foods seldom oftener than once a week; and third, G. S. D., used flesh foods in small amounts about four times a week; and the fourth, W. B. B., had for the six months prior to the experiment used "about as much as one chop once a day," and the year previous had not used any flesh foods. He used beans freely, and urine analysis showed that he was moderately high in protein, excreting an average of 14 grams of nitrogen daily.*

* In view of the fact that this man was moderately high in protein and used a little flesh food daily, I was in doubt whether it would not have been better to classify him among the flesh-eaters. He was finally placed with the flesh-abstainers, for the reason that he offered less contrast to them than to the flesh-eaters. Had he been classified in the other category, the comparisons and conclusions would not have been affected. This is shown below, not only with respect to him, but with respect also to the other two subjects, G. S. D. and I. F., who are classified as abstainers from flesh foods, though using them occasionally.

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The term "flesh-abstainer" is employed in this article in preference to "vegetarian," since the latter term properly means an abstainer from all animal foods (even eggs, milk, cream, and butter), and since it usually suggests a person who abstains not on hygienic but on religious, ethical, or theological grounds. The term "flesh" is used in preference to "meat" in order to include in its scope all animal tissue such as fowl, fish, and shell-fish. The term "abstainer" is used relatively; three of the "abstainers" included were not total abstainers.

The experiment furnished a severe test of the claims of the flesh-abstainers. A preliminary and superficial observation seemed, much to my surprise, to substantiate these claims. Two comparisons were planned, one between flesh-eating athletes and flesh-abstaining athletes, and the other between flesh-eating athletes and flesh-abstaining sedentary workers. The first comparison, being between classes similar as to the element of physical exercise, is fair to both sides. The second puts the flesh-abstainers at a disadvantage; for, other things being equal, sedentary men have much less endurance than men in training. This heavy handicap was placed upon the "abstainers" intentionally, in order to give them a more severe and decisive test, in case the first comparison (between picked athletes of both classes) should turn out in their favor. It is recognized in inductive logic, as in racing, that after a preliminary trial the handicap should be placed on the stronger side, if its superiority is to be put beyond peradventure.

The result of the comparisons given below would indicate that the users of low-protein and the non-flesh dietaries have far greater endurance than those who are accustomed to the ordinary American diet.

In the absence of any exact mechanical method of measuring endurance, three simple endurance tests were employed: first, holding the arms horizontally as long as possible; second, deep knee bending;

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third, leg-raising with the subject lying on his back. All of these tests were made before witnesses.

The accompanying tables give the results for these three tests respectively. It will be observed that there were fewer tests for the "leg-raising" and "deep knee bending" than for "holding the arms horizontally." The reason was that the tests proved unexpectedly painful, and in the case of deep knee bending had distressing after-effects, such as inability to climb stairs and soreness for a number of days. These conditions, as soon as discovered by prospective subjects, made most of them very reluctant to submit to such tests.

The first comparison (for arm holding) shows a great superiority on the side of the flesh-abstainers. Even the *maximum* record of the flesh-eaters was barely more than half the *average* for the flesh-abstainers. Only 2 of the 15 flesh-eaters succeeded in holding their arms out over a quarter of an hour; whereas 22 of the 32 abstainers surpassed that limit. None of the flesh-eaters reached half an hour, but 15 of the 32 abstainers exceeded that limit. Of these, 9 exceeded an hour, 4 exceeded two hours, and 1 exceeded three hours.

In respect to deep knee bending, if we take the number 325 for reference, we find that, of the 9 flesh-eaters only 3 surpassed this figure, while of the 21 abstainers, 17 surpassed it. Only 1 of the 9 flesh-eaters reached 1,000 as against 6 of the 21 abstainers. None of the former surpassed 2,000 as against 2 of the latter.

In respect to leg-raising, the records show little difference. None of the contestants reached their absolute limits. The highest record for the abstainers is 1,000 times. That this was not near the limit was evidenced by the repetition of the performance on each of several successive days. The flesh-eater who reached 1,302 did so after the 1,000 mark had already been set for him and with the express intention of exceeding it. It was evident from

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his fatigue at the end that he could not have repeated the performance on the next day as did his rival. Both these men had made a specialty of

FIRST ENDURANCE TEST: HOLDING ARMS HORIZONTALLY

FLESH-EATERS			FLESH-ABSTAINERS†			
ATHLETES‡			ATHLETES‡		SEDENTARY	
NAMES		TIME IN MINUTES	NAMES	TIME IN MINUTES	NAMES	TIME IN MINUTES
L. B. Yale	6**		H. Bat. Cr.	6	J. T. C. Bat. Cr.	10
F. O. "	7**		N. "	6	E. L. E. "	10
C. H. O. "	7		A. B. "	10*	E. H. R. "	15
R. M. B. "	7		J. "	10	A. J. R. "	17
R. Ba. "	7		J. P. H. "	12	S. E. B. "	27
G. "	8		B. S. S. "	13	† I. F. Yale	37
F. S. N. "	8		S. "	13	P. R. Bat. Cr.	42
W. J. H. "	9*		H. O. "	13*	J. F. M. "	51**
E. J. O. "	10		† W. B. B. Yale	16**	H. G. W. "	80
J. H. D. "	10		C. H. Bat. Cr.	17	C. E. S. "	80
R. Bu. "	10		R. M. M. "	18	J. E. G. "	98*
H. A. R. "	12		O. A. "	21	A. W. N. "	170
C. S. M. "	14*		S. A. O. "	32	E. J. W. "	200
R. "	18		M. "	35		
G. K. "	22*		D. "	37		
			W. W. Yale	68		
			W. Bat. Cr.	75		
			† G. S. D. Yale	160		
			C. C. R. Bat. Cr.	176*		
Average	10			89		64

* Limit of endurance.

** Nearly to limit; arms trembling.

† As previously stated, there is some reasonable doubt as to whether W. B. B., who consumed a small amount of flesh food daily, should be classified among the abstainers or the users of flesh foods. In the above tables, he is classified in the former category, but if he were transferred to the other side, the averages would be only slightly affected, changing from 10 vs. 89 to 11 vs. 40. The same doubt in less degree applies to the subject, G. S. D., who consumed flesh foods about four times a week. But even his heavy record (160), if transferred to the opposite side of the balance, would only change the averages to 20 vs. 32. The only other person classified as an abstainer who used flesh foods at all was I. F., whose use was less often than once a week. Should he likewise be transferred to the flesh-eaters, the comparisons would merely be changed to 21 vs. 32.

‡ The term "athlete" is used in the tables to signify a person who is in daily training, whether preparing for an athletic contest or not. In the case of the flesh-eating "athletes," all with three exceptions were training for athletic contests. In the case of the abstainers, very few of them were training for such a purpose. They consisted, for the most part, of the nurses and employees of the Battle Creek Sanitarium, who, by occupation or choice or both, were physical culturists.

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developing their abdominal muscles. Only one of the sedentary group of abstainers took the leg-raising test. His record was far below that of the flesh-eating athletes, being 74 as against 279.

There remain two questions: First, are the figures in the accompanying tables a true index of the relative endurance of the groups of men considered?

SECOND ENDURANCE TEST: DEEP KNEE BENDING

FLESH-EATERS		FLESH-ABSTAINERS†			
ATHLETES		ATHLETES		SEDENTARY	
NAMES	Times	NAMES	Times	NAMES	Times
R. (Yale)	102	N (Bat. Or.)	151	A.J.R. (Bat.Cr.)	200
F. O. "	130	W. "	185	P. R. "	400
J. H. D. "	137	S. "	220	J. T. C. "	401
C. H. C. "	200	A. B. "	380	E. J. W. "	447
G. K. "	254*	D. "	463	J. F. B. "	1225
W. J. H. "	318	M. "	588		
C. S. M. "	502*	J. "	600		
F. S. N. "	575	J. P. H. "	770		
G. A. "	1229	C. H. "	791		
		H. O. "	800		
		B. S. S. "	801		
		O. A. "	1000		
		H. "	1708		
		W. W. (Yale)	1800		
		R. M. M. Bat.Cr.	2270		
		S. A. O. "	2400		
Averages	383		927		535

* Was limit of endurance; C. S. M. fainted.

† In this table all the "abstainers" were total abstainers.

THIRD ENDURANCE TEST: LEG RAISING

FLESH-EATERS		FLESH-ABSTAINERS†			
ATHLETES		ATHLETES		SEDENTARY	
NAMES	Times	NAMES	Times	NAMES	Times
G. (Yale)	24	J. (Bat. Or.)	37	B.N.O. (Bat.Cr.)	74
L. B. "	31	A. B. "	44		
R. M. B. "	98	B. S. S. "	90		
R. Ba. "	104	D. "	250		
R. Bu. "	115	†W.B.B. (Yale)	305		
J. M. T. "	1302	H.O. (Bat. Cr.)	1000		
Averages	279		288		74

† As previously stated, there is reasonable doubt as to whether or not W. B. B. should be classified as an abstainer. If he were transferred to the other side of the comparison, the averages would merely change from 279 vs. 288 to 283 vs. 284.

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and second, if so, is the difference in endurance thus displayed due to the dietetic causes mentioned or to some other factor?

The necessity of raising the first question has been pointed out with much emphasis by Caspari, who in his *Physiologische Studien über Vegetarismus** states that vegetarians are usually so determined to prove the correctness of their principles and to spread their propaganda, that they make a far greater effort in any contest than do their meat-eating rivals. He points out that in the foot races in Germany between vegetarians and meat-eaters, some of the latter have dropped out when not really exhausted and given the victory to the former, who have heroically stayed by their guns. It is undoubtedly true that grit counts for much in most contests of endurance, and that it is possible to mistake a superiority in grit for a superiority in muscular endurance. Such an hypothesis in the present case, however, would not serve to explain the facts. It is true that a few of the flesh-abstainers, notably H. O., A. W. N., and J. F. M., exhibited the spirit mentioned by Caspari; and it is also true, that one of them, H. O., tried hard to infuse this spirit into others. But most of the abstainers were less influenced by the desire to vindicate their dietetic system than by the rivalry with individuals—the spirit of the sportsman. Thus, in

GENERAL COMPARISONS

	ARM HOLDING		DEEP KNEE BENDING		LEG RAISING	
	No. of Persons	Average Record	No. of Persons	Average Record	No. of Persons	Average Record
Flesh-eaters, athletes....	15	10 Min.	9	383 Tms.	6	279 Tms.
Flesh abstainers, athletes	19	39 "	16	927 "	6	288 "
Flesh abstainers, sedentary	13	64 "	5	535 "	1	74 "

* Bonn, Verlag von Martin Haager, 1905.

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a general way, the *later* tests showed better records than *earlier tests*, for the reason that the subjects were constantly trying to break previous records. All the large records, with one exception, were brought about in this way.† The advantage to those who took the later tests, in having a mark set for them to reach or surpass, is shown in the comparisons between the two groups of abstainers, the sedentary and the athletic. It can scarcely be supposed that the sedentary physicians had actually greater endurance than the athletes. Yet in one of the tests (arm-holding) the sedentary men had the higher record. This is ascribable to the fact that the sedentary men were tested after the records of the athletes were known. The athletes had been tested on January 21, 26, and 30, and one on February 16. The sedentary men were tested on February 13 to 16. Thus, with one exception, the athletic group of abstainers had completed their test before the sedentary group began; that exception, the athlete C. C. R., reached the highest record but one, namely, 176 minutes. The sedentary men had therefore the greater spur of competition. The spur is especially needful in the painful arm-holding test. The final holder of the record was the last man to be tested, Dr. E. J. W. His record was 200 minutes. In the other tests, deep knee bending and leg-raising, the athletes maintained the higher records.

The case of S. A. O. is instructive, both as showing the importance of the competitive factor and as showing the unimportance or comparative absence of the factor mentioned by Caspari, the desire to vindicate a cause. Mr. S. A. O. is a nurse at Battle Creek, possessing great strength and endurance, but, being one of the first to be tested, and, having no previous records to break, he held his arms out

† The exception was the case of the Yale low-protein athlete, G. S. D., who, in arm holding, reached 160 minutes, or 2 hours and 40 minutes, although no previous contestant had then attained more than 87 minutes.

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only 9 minutes and 10 seconds. This was very far from his limit, for after it had been surpassed by some of his associates, he did it 32 minutes, which was at that time "the record." In like manner, in deep knee bending his first test was only 147, but afterward, under the stimulus of competition, he raised it to 2,400, and stated that if this record were ever broken, he wished to have the opportunity to try again.

In another case, that of the Yale student, G. S. D., there was no thought of "vegetarianism"; he had practically dropped meat out of his dietary from reasons of economy, and was much surprised after his test was over to hear the suggestion that his endurance might be due to this abstemiousness. In these cases, therefore, and in many others which might be cited, the stimulus was the stimulus of rivalry, not the desire to vindicate a theory.

The advantage of this factor of rivalry as between the flesh-eaters and the abstainers was distinctly on the side of the flesh-eaters; for their tests, with two exceptions, came after all the records of the abstainers had been completed, namely, February 28, April 4, May 9 to 31. The two exceptions were of men tested on February 9, and even these men had a large number of previous cases to stimulate them, including that of the Yale abstaining athlete who had reached 160 minutes. It is also to be remembered that the Yale athletes were, as such, more accustomed to undergo physical torture for the sake of winning an athletic contest, than were their rivals at Battle Creek. Few, if any, of the latter worked as hard as G. K. and F. O., the baseball players; W. J. H., the runner; J. M. T. and G. A., the crew men; and C. S. M., the wrestler, all of Yale.

It is, therefore, practically certain that as a whole the flesh-eaters worked nearer to their limits than the abstainers, and it is certain that a larger proportion of flesh-eaters actually reached their limit

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than of the abstainers. Of the 15 flesh-eaters who took the arm test, 3 reached their limit; of the 32 abstainers who took the same test, only 4 reached their limit. Again, of the 9 flesh-eaters who took the deep knee bending test, 3 reached their limit; and of the 21 abstainers who took the deep knee bending test, none reached their limit. In the leg-raising test, no one reached the absolute limit.

Except on the part of three or four of the Battle Creek men, there was little evidence of that fanatical desire to prove the superiority of vegetarianism on which Caspari comments in Germany. But in view of Caspari's warning, special pains were taken to stimulate the flesh-eaters to the utmost. This stimulation was brought about, in the case of Yale students, by utilizing their college pride. They felt that their tests would go on record as tests of Yale athletes, and the "Yale spirit" appeared to be as great a stimulus as any "vegetarian" spirit could possibly be.

An effort was made to bring individuals representing the two diets in direct competition, although this was possible in only two cases. In one case a Yale long-distance runner and a Yale professor who had adopted the Chittenden diet met in competition in the arm contest. The athlete was a high-protein flesh-eater. In the course of a few minutes his arms began to tremble, and at the end of 8 minutes and 54 seconds they had gradually fallen, against his will and much to his mortification. The arms of his antagonist had not yet begun to tremble or even to give much pain in the deltoid, and he continued holding them out for 37 minutes. In another case, a physician from New Haven, who accompanied me on one of the trips to Battle Creek, was pitted against a physician of the Sanitarium. The New Haven physician was of a more athletic build than his antagonist and, in college, had been a football player. In physique and former training, in out-of-door life, in age and every other material

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respect except diet, he seemed to have the advantage. But in diet he was accustomed to eating meat three times a day, whereas his antagonist had abstained from meat for 20 years and was on a low-protein basis (.105 grams of nitrogen per kilogram of body weight—the Chittenden standard). In order that the flesh-eater might have the greater stimulus, he was started on his test one minute later than his opponent. He therefore realized that if he dropped his arms first he was beaten, whereas his opponent, had he dropped his arms first, still had a chance of winning. The flesh-eater certainly exercised strong will-power, but at the end of 12 minutes he was unable to hold out longer. His opponent continued to 17 minutes, and had he made the same effort, would undoubtedly have continued much longer.

Another evidence that the superiority of the flesh-abstainers was one of muscular endurance and not of grit was the fact that there was less pain felt by them in the arm-holding test. In the cases of all the flesh-eaters, the pain in the deltoid began very early, and this pain, when it once began, remained, though with some fluctuations, to the end. Among the abstainers, on the other hand, the case was different. The pain began later and fluctuated more widely. In only one case, that of Dr. H. G. W., did the pain begin early and continue without cessation to the end (80 minutes). Dr. C. E. S. felt almost no sensation of pain for a full hour. In the case of Dr. A. W. N., the pain began almost from the outset, but continued to go and come for the full time, namely, 2 hours and 50 minutes. Dr. E. J. W. felt very little pain for 2 hours and kept the arms up for 3 hours and 20 minutes. This time was chosen, not because it was the limit of endurance, but because it was a round number (200 minutes.) In fact, the arms were not trembling even at the end, although there was a great deal of pain and had been for the previous half hour.

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In this connection it might be mentioned that a six-year-old son of one of the Battle Creek doctors, who heard of his father's test, tried holding his little arms out, and did not drop them until 43 minutes had elapsed. It would, of course, be absurd in this case to attribute to the child any effort to vindicate "vegetarianism." It was only the pain which induced him to drop his arms, and undoubtedly it required a much less degree of pain to produce this effect in his case than in the case of adults.

Still other evidence is found in a study of the after-effects. From arm-holding, there were, curiously enough, very little after-effects, either in the case of the flesh-eaters or the abstainers. But deep knee bending left painful after-effects with all, though they were far more marked for the flesh-eaters than for the abstainers. Thus, among the latter, those who held two of the three highest records, 1,800 and 2,400, were not incapacitated. The former, who is a Yale athlete, took a run on the track of the gymnasium after his performance, and a long walk afterward; and the latter, who is a nurse at the Sanitarium, continued his duties and found little annoyance from stiffness or soreness. On the other hand, among the flesh-eaters, G. K. had reached his absolute limit at 254 times, and was unable to rise from a stooping posture the 255th time. He had to be carried downstairs after the test, and was incapacitated for several days. The same was true of C. S. M., who, in fact, was seriously alarmed about his condition for two weeks. He had fainted after 502 deep knee bendings. Again, W. J. H., the long-distance runner, was so stiff and sore and inconvenienced that he and his trainers feared that he would not be able to compete in races for which he had been scheduled some weeks later. Fortunately these fears proved groundless.

Finally, satisfactory evidence that the difference in endurance between the groups mentioned was not

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due to a superiority in grit on the part of the abstainers is found in the fact that, even if we compare the flesh-eaters who actually *reached their limit* in the various tests with the abstainers who did *not* reach their limit, the latter group will show themselves superior. The results are given in the following tables:

SELECTED COMPARISONS, GIVING EVERY BENEFIT OF THE DOUBT TO THE FLESH-EATERS*

	ARM HOLDING		DEEP KNEE BENDING	
	No. of Persons	Average Record	No. of Persons	Average Record
Flesh-eaters, athletes.....	4**	16 Min.	5 a	576 Times
Flesh-abstainers, athletes.....	17***	31 "	16 b	933 "
Flesh-abstainers, sedentary....	12****	62 "	5 c	585 "

* Every flesh-eater is included who continued to his *limit of endurance* and any others who would *raise* the average. Every abstainer is included who *stopped short of his limit* and any others who would *lower* the average.

** Viz., W. J. H., C. S. M., G. K., and R.

*** Viz., all except C. O. R.

**** Viz., all except J. E. G.

a Viz., G. K., W. J. H., C. S. M., F. S. N., G. A.

b Viz., all without exception.

c Viz., all without exception.

The conclusions from this table are:

(1) The average record of the flesh-eaters whose arms were held out until they dropped was only about half the average record of the abstaining athletes, and a quarter of the average record of the abstaining sedentary men, who stopped short of their limit, though the flesh-eaters were helped out by including others of their number who would raise their average, and the abstainers were handicapped by including any who would lower theirs.

(2) Comparisons of the same nature for deep knee bending show the flesh-eaters' average to be less than two-thirds that of the abstainers of the same class, and only 7 per cent above that of the sedentary class.

Allowing for the heavy handicaps placed on the winning side, it may be inferred without reasonable doubt that the flesh-eating group of athletes was

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very far inferior in endurance to the abstainers, even the sedentary group.

There still remains the question whether this difference in endurance was due to the dietetic factors mentioned, or to some other cause. In order to determine whether some other cause than diet could be responsible for so marked a difference in endurance, we may use the method of elimination.

In the first place, it is certain that the difference was not a matter of exercise. There can be no doubt, of course, that exercise is a most important factor in producing endurance. This is proved every year by those training for endurance contests. Evidence of the influence of exercise may be seen in the present tests. Thus the best record for holding the arms in the case of the flesh-eaters was that of a baseball player, whose right deltoid was exercised in playing ball. It was noticeable, in his case, that there was a great difference between the right and the left arm, the latter being the one which brought the test to an end, although it was undoubtedly stronger than the deltoid of sedentary persons.*

Again, the two highest records for the leg-raising were made by men who had exercised the abdominal muscles systematically, one of them training for the Yale crew. His was the only case in which the highest record for any one of the three tests was held by a flesh-eater.

But that exercise was not responsible in the present experiment for the disparity in endurance is shown by the fact that even the *sedentary* abstainers surpassed the *exercising* flesh-eaters. The sedentary abstainers were in most cases physicians, and with few exceptions took very little exercise, but spent their entire day in their offices at the Sanitarium. This was the case even with Dr. J. F. B., who reached the record of 1,225 in deep knee bending.

* There is a sympathetic relation between corresponding muscles. A physiologist has told me of experiments he has tried on himself, which seem definitely to show that the exercise of a muscle on one side increases the endurance not only of that muscle but also of its unused mate on the other side.

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Again we cannot attribute the result to more sleep or leisure on the part of the abstainers. Here, too, the advantage was all on the side of the flesh-eaters, who, as students, had more freedom and as athletes were taking every effort to keep good hours and live hygienically for the sake of the contests for which many of them were training. Among the abstainers, at any rate the sedentary group, the opposite conditions prevailed. Several of the physicians had night duty or for other reasons were on short sleep. In fact, it was because I had noticed their unusual capacity for long hours that the comparisons described in this article were undertaken. Similar comments had been made by other observers, including several physicians. For instance, a Yale instructor and physician, who had been accustomed for years to spend his summers at Chautauqua, and who had many in his classes from the Sanitarium, commented upon the fact that they had greater endurance than the rest of his class. He stated that they did all the work which the others accomplished and usually two hours extra daily.

Again the difference in endurance is not attributable to a difference in physique. Here also the advantage was distinctly on the side of the flesh-eaters; in fact, the abstainers, as far as they consisted of men at the Sanitarium, were for the most part ex-invalids. Two had had in years past tuberculosis of the lungs, one had had hip disease, another typhoid fever, etc. In respect to physical appearance, they were in general inferior to their flesh-eating competitors at Yale.

Alcohol and tobacco could scarcely be the cause of the inferiority of the flesh-eaters, inasmuch as, being in training, they were for the time at least practically abstaining from their use.

The only other questionable factor is fresh air. In this respect there is less certain evidence, but as far as the use of fresh air in the daytime is con-

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cerned, there can be little doubt that the flesh-eaters had here the advantage also; for the training of the Yale athletes usually involves outdoor runs, and in all cases it involves the exercise of the lungs in connection with other exercises; whereas the sedentary flesh-abstainers were, as above stated, confined indoors for the entire day. With respect to the use of fresh air at night, it is quite possible that the advantage was on the side of the flesh-abstainers. This was certainly true in a few cases, especially among the abstaining athletes, one of whom slept in a tent at Battle Creek.

It must not be forgotten that the four Yale abstainers showed just as great a superiority in endurance to the flesh-eaters as did the 28 abstainers at Battle Creek, although at least two of the four were, as far as known, under the same conditions as to fresh air and other conditions of training. While, therefore, it is not possible to speak with absolute certainty as to the influence of fresh air upon the comparisons, there is no evidence to show that this factor favored the abstainers as a whole, or, if it did favor this group, that it played so important a role as to explain, unaided, their great superiority in endurance.

It seems reasonable, therefore, to attribute the difference in endurance between the flesh-eaters and the abstainers entirely to the difference in their diet.

The question still remains, What were the essential dietetic factors? It is well known that the Battle Creek subjects differ in their diet from other persons not only in their abstention from flesh, but also in their abstention from tea, coffee, condiments—such as mustard, pepper, etc.—and in the fact that their protein is on a considerably lower level. It is impossible, on the basis of the comparisons presented, to give a definitive statement as to the relative importance of these various factors. The contrast in the groups in respect to the use of flesh

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is closely associated with the contrast in respect to the amount of protein. That the subjects from Battle Creek are lower in protein will be seen from the accompanying table, which gives the average daily nitrogen excreted per kilogram of body weight.

NITROGEN EXCRETED BY FLESH-ABSTAINERS

	NITROGEN PER KILO.	ARM HOLDING	DEEP KNEE BENDING
J. E. G., Battle Creek.....	.095	98 Min.	...
E. J. W., " " .....	.10	200 "	447 Times
J. F. B., " " .....	.105	...	1225 "
A. J. R., " " .....	.105	17 "	200 "
H. O., " " .....	.11	18 "	800 "
A. W. N., " " .....	.115	170 "	...
J. T. C., " " .....	.117	10 "	401 "
O. H., " " .....	.120	17 "	791 "
E. H. R., " " .....	.122	15 "	...
J. F. M., " " .....	.125	51 "	...
S. E. B., " " .....	.125	27 "	...
S. A. O., " " .....	.135	32 "	2400 "
C. E. S., " " .....	.14	80 "	...
P. R., " " .....	.15	42 "	400 "

This table is interesting in several ways. It shows that the diet of the Battle Creek men was low in protein as compared with the ordinary American diet, which metabolizes .18 to .24 gram per kilogram. Their great endurance, therefore, may possibly be explainable wholly on the ground of low-protein and not on the ground of abstention from flesh foods *per se*. Practically speaking, however, a flesh-eater cannot maintain these low levels of protein unless his consumption of flesh foods is at most very small. On the other hand, it is conceivable that the difference in endurance is due to the difference in the use of flesh foods *per se*. In this case the abstainers might have still more endurance if they consumed more vegetable protein. Evidence based on other data than those here presented would seem to show that *both* low-protein and flesh-abstention are favorable to endurance. But there is little evidence in the facts given in this article to enable

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us to disentangle the possible virtues of a low-protein diet and of a non-flesh diet. Some slight evidence of the importance of low-protein is found by dividing, in the above table, the records for each of the two tests into two equal groups, a low-protein group and a high-protein group. We find the following averages:

GROUP	ARM HOLDING*	DEEP KNEE BENDING
Low protein	85	668
High protein	41	998

* Since, for this test, the number of men was odd, the middle man, C. H., was omitted; but his inclusion in either group would not materially affect the comparison.

No great dependence can be placed on these comparisons, because they are somewhat conflicting, because the possible unequal effect of competition has not been eliminated and because the two groups do not differ very markedly in protein.

From the experiments as above described, we may now draw the following conclusions.

First: Of the three groups compared, the large flesh-eaters showed far less endurance than the abstainers, even when the latter were leading a sedentary life. *A fortiori*, must the large flesh-eaters of the sedentary type be inferior in endurance to abstainers.

Second: In view of (1) the great extent of the superiority shown, (2) the heavy handicap imposed upon the abstainers, and (3) the absence of other known factors to account for their superiority, it is improbable that this superiority can be explained away by adventitious circumstances.

Third: It is possible that the superiority of the abstainers is due to the absence of flesh foods or to the use of a smaller amount of protein, or to both as well as to the abstention from tea, coffee, and condiments.

No attempt has been made to explain why the use of high-protein or flesh foods should diminish

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endurance. A number of theories have been proposed. Dr. Alexander Haig, of London, has long maintained that abstainers have greater endurance than flesh-eaters, particularly if they abstain also from all other "uric-acid-producing foods" such as (he says) eggs, beans, peas, asparagus, and mushrooms. His principal theory is that uric acid is the factor in diet which induces fatigue. Many of his theories, both as to uric acid and as to the requirements of protein, have been overthrown; but his claims for the advantages of a purin-free—or at any rate a fleshless—dietary have received much corroboration. The manner in which, according to Haig, uric acid interferes with endurance is by making the blood "collemic" or viscous, whereby it becomes difficult for the heart to pump it through the capillaries. Hence the blood-pressure increases. Observations actually show that persons possessing great endurance often have low blood-pressure. This is true, for instance, among the subjects of the present experiment at Battle Creek.

A more general theory than that of Haig is that flesh foods contain in themselves "fatigue poisons" of various kinds, which naturally aggravate the action of the fatigue poisons produced in the body.

Still another theory in favor of the use of low-protein is that mentioned by Professor Chittenden in his *Physiological Economy in Nutrition*, and concerns the metabolism of protein. As is well known, fat and carbohydrate, when consumed, give off merely carbonic acid gas and water, both of which are easily eliminated, the one being a gas and the other a liquid. Protein, on the other hand, produces crystalline waste products, of which uric acid is one. The theory is that these midway products of metabolism in some manner produce fatigue. When the problem of the physiology of fatigue and its relations to food ingested is more fully solved, it will not only satisfy a legitimate scientific curiosity, but will point unmistakably to the optimum diet

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under various conditions. In the meantime, it may be said that, whatever the explanation, there is strong evidence that a low-protein, non-flesh, or nearly non-flesh, dietary is conducive to endurance.

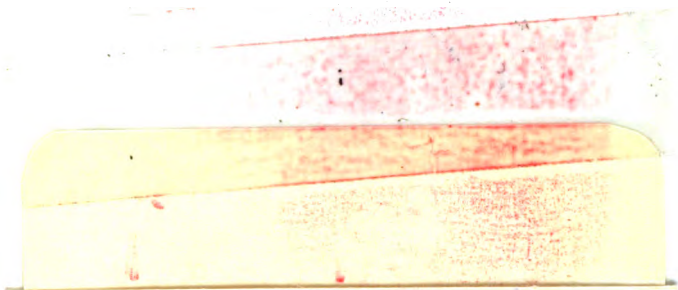
The truth of this result has been long obscured, through two unfortunate circumstances. One is the vegetarian fanaticism mentioned by Caspari, which has done much to defeat its own ends. From the premise—often bolstered up by theological dogma—that flesh-eating is wrong, the inference is drawn that it must be unhygienic. This reasoning is so utterly at variance with the methods of modern science as to stamp those who use it as victims of bigoted prejudice, and to prevent any genuine scientific investigation. At present the tendency of such investigations as those of Chittenden, Mendel, Folin, Metchnikoff, Caspari, Le Fevre, Favel, and others have a distinct trend toward a fleshless dietary. And yet, such are the associations of the term “vegetarian,” that many are loath to grant even what is due to the tenets of “vegetarianism.” The proper scientific attitude is to study the question of meat-eating in precisely the same manner as one would study the question of bread-eating.

The second circumstance which has obscured the merits of a low-protein and non-flesh diet is that many of those who have attempted experimentally to give up flesh foods have made themselves ill. The reason formerly given for this effect was “deficiency of protein,” but, in view of the researches of Pawlow and other recent writers, we may be fairly certain that such failures are usually due to the fact that meat is a highly peptogenic food. It follows that, when it is suddenly or forcibly cut out of one’s diet, the stomach feels the lack of its accustomed stimulus. There seem to be practical advantages in the method of reaching a low-protein diet adopted by Mr. Fletcher, consisting of thorough mastication. The experiment last year at Yale as well as other experiments have shown that

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adherence to this practice leads to a gradual reduction in protein and flesh foods, without any unpleasant or dangerous self-denial on the part of the experimenter. It may well be that those who, in spite of thorough mastication, still have a craving for flesh foods have an actual physiological need which no other foods—at least in the list of foods employed by them—is able to satisfy. The question of the extent to which flesh foods may be used advantageously is still open, but there can now be little question, in view of the facts which have come to light during the last few years, that the ordinary consumption of those foods is excessive.

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